PATENT ABSTRACTS OF JAPAN

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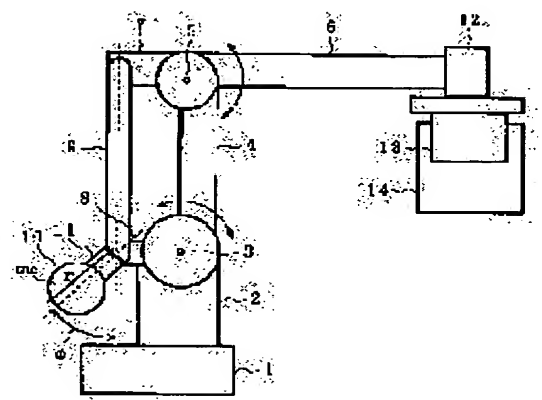
(54) MULTI-JOINT ROBOT

(57)Abstract:
PROBLEM TO BE SOLVED: To optimize a mounting position of a weight when gravity load of a first arm and a second arm is reduced simultaneously by using the weight by providing a lower end joint of a rear joint attached to one end of the rear joint so that the other end thereof keeps a specified angle for the rear joint and the weight attached to the other end of the lower end joint.
SOLUTION: When a first turn shaft 3 turns and a first arm 4 falls down forward, a lower end joint 11 of a rear joint becomes a moment arm to raise the first arm 4 due to mass of a weight 10 concerning the first turn shaft 3, reducing gravity load of the first arm. Moreover, when a second turn shaft 5 turns and a second arm becomes horizontal, a lower joint 8 becomes a moment arm to raise the second arm 6 due to mass of the weight 10 concerning the second turn shaft 5, reducing gravity load of the second arm 6. When the gravity load of the first arm 4 and the second arm 6 is reduced simultaneously, the angle ϕ for the rear joint 9 of the lower end joint 11 of the rear joint and the length r of the lower end joint 11 of the rear joint are changed.



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CLAIMS

[Claim(s)]
[Claim 1] The many articulated robots characterized by providing the following. The 1st rotation shaft held free [rotation] within the vertical plane at the robot drum section. The 1st arm which an end is stopped by the rotation shaft of the above 1st and is rotated to the circumference of the rotation shaft of the above 1st. The 2nd rotation shaft held free [rotation] within the vertical plane at the other end of this 1st arm. The 2nd arm which it has a grasping means to grasp a work at the end, is stopped by the rotation shaft of the above 2nd, and is rotated centering on the rotation shaft of the above 2nd, The lower paragraph stopped by the rotation shaft of the above 1st so that an end could rotate freely to the circumference of the rotation shaft of the above 1st and it might become the 2nd arm of the above, and parallel, The deutomerite in which the other end is supported by the other end of the bottom paragraph of the above, and forms parallel the link of Section 4 with the 1st arm of the above, the 2nd arm of the above, and the lower paragraph while an end is supported by the other end of the 2nd arm of the above, The weight attached in the other end of the deutomerite soffit paragraph attached in the other end of the above-mentioned deutomerite so that an end might hold the above-mentioned deutomerite and a predetermined angle, and this deutomerite soffit paragraph.
[Claim 2] The many articulated robots according to claim 1 characterized by determining the length of the angle and the above-mentioned deutomerite soffit paragraph over the deutomerite of a deutomerite soffit paragraph, and the mass of a weight with the gravity which acts on the torque and the 1st arm, the 2nd arm, the lower paragraph, and deutomerite soffit paragraph of the angular acceleration of the 1st rotation shaft and the 2nd rotation shaft, the 1st rotation shaft, and the 2nd rotation shaft.
[Claim 3] The length of the angle and the above-mentioned deutomerite soffit paragraph over the deutomerite of a deutomerite soffit paragraph, and the mass of a weight The many articulated robots according to claim 1 characterized by what the gravity which acts on the torque and the 1st arm, the 2nd arm, the lower paragraph, and deutomerite soffit paragraph of the angular acceleration of the operating time of the 1st rotation shaft and the 2nd rotation shaft, the 1st rotation shaft, and the 2nd rotation shaft, the 1st rotation shaft, and the 2nd rotation shaft determines.
[Claim 4] The many articulated robots according to claim 2 or 3 characterized by limiting the operating range to which a robot actually works, and determining the length of the angle to the back paragraph of the back paragraph soffit paragraph, and the paragraph soffit paragraph after the above, and the mass of a weight.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention relates to many articulated robots, especially the perpendicular many articulated robots of an parallel link formula.
[0002]
[Description of the Prior Art] It is the robot drum section by which 1 was prepared in a robot's pedestal and 2 was prepared on this pedestal 1, and a revolution drive is carried out [in / drawing / drawing 10 is the block diagram showing the conventional many articulated robots, and] by the robot drum section driving source (not shown). The 1st rotation shaft with which 3 was pivoted in the robot drum section 2, and 4 are the 1st arm, it is fixed to the 1st rotation shaft 3, and the soffit of this 1st arm 4 rotates to the circumference of the 1st rotation shaft 3 by the 1st rotation shaft driving source (not shown). The 2nd rotation shaft with which 5 was pivoted by the 1st arm 4, and 6 are the 2nd arm, it is fixed to the 2nd rotation shaft 5, and this 2nd arm 6 is rotated centering on the 2nd rotation shaft 5 by the 2nd rotation shaft driving source (not shown). 7 is the 2nd arm back end paragraph, and is the portion which extended the 2nd arm 6 from the 2nd rotation shaft 5 to back (the side to which a robot works is made into the front). The lower paragraph with which 8 was connected free [the rotation to the circumference of the 1st rotation shaft 3] for an end, and the other end was connected with the deutomerite 9 free [rotation], and 9 are deutomerite which connects the edge of 2nd arm back end Section 7, and the edge of lower Section 8 so that it may become parallel to the 1st arm 4. The 1st arm 4, 2nd arm back end Section 7, lower Section 8, and the deutomerite 9 have accomplished the parallel link of Section 4 here. 10 is the weight prepared in the deutomerite 9 attachment side edge section of lower Section 8. In addition, the many articulated robots shown in drawing 10 are called conventional example 1.
[0003] Next, operation is explained. While working by a robot rotating the robot drum section 2, the 1st arm 4, and the 2nd arm 6, respectively by the robot drum section driving source, the 1st rotation shaft driving source, and the 2nd rotation shaft driving source, the mass of a weight 10 tends to take down lower Section 8 below, lower Section 8 tends to lengthen the deutomerite 9 below, and the deutomerite 9 tends to lower 2nd arm back end Section 7. Therefore, about the 2nd rotation shaft 5, lower Section 8 becomes a moment arm and the load by the gravity of the 2nd arm 6 is mitigated by the mass of a weight 10.
[0004] Drawing 11 is the block diagram showing the parallel link formula perpendicular many articulated robots shown in JP,1-121682,U, in drawing, 20 is the 1st arm soffit section which is the portion caudad extended from the 1st rotation shaft 3 of the 1st arm 4, and the edge is connected with lower Section 8. 21 is a driving source for the 2nd arm rotation of the pivoting point of the deutomerite 9 and lower Section 8, and the mass of this driving source 21 plays a role of a weight. In addition, the same sign is given to the portion equivalent to drawing 10 , and duplication explanation is omitted. Moreover, this is the many articulated robots which improved the conventional example 1, and calls it the conventional example 2 hereafter.
[0005] Although the weight 10 was the same height as the 1st rotation shaft 3 in the conventional example 1 Since there is a driving source 21 for the 2nd arm rotation caudad from the 1st rotation shaft 3 in the conventional example 2 While gravity unloading of the 2nd arm 6 is made like the conventional example 1, about the 1st rotation shaft 3, the 1st arm soffit section 20 becomes a

moment arm, and the load by the gravity of the 1st arm 4 is also mitigated by the mass of the driving source 21 for the 2nd arm rotation.
[0006] Drawing 12 is the gravity balancer of the many articulated robots shown in JP,7-16903,B. This is also the many articulated robots which improved the conventional example 1, and is hereafter called conventional example 3. drawing -- setting -- C'1 The pivoting point of the 1st rotation shaft 3, and C'2 The pivoting point of the 2nd rotation shaft 5, and C'3 The end point of the 2nd arm back end section 7 and the deutomerite 9 and C'4 are equivalent to the end point of lower Section 8 and the deutomerite 9. 11 is an end point C'4. It is the deutomerite soffit paragraph extended caudad, and Weight W is attached in the soffit of this deutomerite soffit Section 11. Therefore, in the conventional example 3, since Weight W is caudad formed from the 1st rotation shaft 3 like the conventional example 2, while gravity unloading of the 2nd arm 6 is made, gravity unloading of the 1st arm 4 is also made like the conventional example 2.
[0007] Furthermore, moment force of acting on each pivoting point (and end point) C'1 to C'4 in this conventional example 3 (in the length of each link) The formula of balance of parallel the link of Section 4 is stood from being determined using the position of mass and the center of gravity, it asks for the mass and the optimal attaching position (drawing 12 the length lW of back paragraph soffit Section 11) of Weight W from this formula, and the static balance and static ** of the circumference of a joint are performed easily.
[0008] Drawing 13 is the block diagram showing the perpendicular many articulated robots using the conventional spring, and 22 is the spring stretched between the upper part of the robot drum section 2, and the 1st arm 4 in drawing. Hereafter, the perpendicular many articulated robots shown in drawing 13 are called conventional example 4.
[0009] In the conventional example 4, if the 1st arm 4 falls on a cross direction, since it is going to return to the state where the extended spring 22 pulled the 1st arm 4, and stood perpendicularly, the load of the gravity to the 1st rotation shaft 3 which is the rotation shaft of the 1st arm 4 is mitigated. In addition, there is a publication-number No. 109087 [one to] official report etc. as what is indicating the many articulated robots which carry out gravity unloading using the conventional spring.
[0010]
[Problem(s) to be Solved by the Invention] Since the conventional many articulated robots are constituted as mentioned above, although the gravity load of the 1st arm 4 and the 2nd arm 6 is mitigated by attaching a weight in many articulated robots like the conventional example 1 and the conventional example 2 Necessarily, the attaching position of a weight is not the optimal in order to mitigate a gravity load. in many articulated robots like the conventional example 3 Since the optimal attaching position and mass of a weight are determined from the formula of balance of static parallel link of Section 4, without taking into consideration the case where the robot is actually operating (work) The mass of a weight became heavy too much, the moment of inertia of an arm increased with the mass of a weight, it becomes impossible to have taken large acceleration torque, and technical problems, like the operating time becomes late occurred. Moreover, in many articulated robots like the conventional example 4, cost went up by using a spring 22, and the technical problem of a robot's life being restricted from the life of a spring occurred.
[0011] In case it was made in order that this invention might solve the above technical problems, and the gravity load of the 1st arm and the 2nd arm is simultaneously mitigated using a weight, it aims at obtaining the many articulated robots which can make the attaching position of a weight the optimal. Moreover, in case this invention determines the optimal attaching position and mass of a weight, it aims at obtaining the many articulated robots which make the minimum fall of the angular acceleration of the 1st arm and the 2nd arm, or increase of the acceleration time.
[0012]
[Means for Solving the Problem] The many articulated robots concerning invention according to claim 1 are equipped with the back paragraph soffit paragraph attached in the other end of the back paragraph so that an end might hold the back paragraph and a predetermined angle, and the weight attached in the other end of a paragraph soffit paragraph after this.
[0013] The many articulated robots concerning invention according to claim 2 determine the length of the angle and the back paragraph soffit paragraph over the back paragraph of the back paragraph

soffit paragraph, and the mass of a weight with the gravity which acts on the torque of the angular acceleration of the 1st rotation shaft and the 2nd rotation shaft, the 1st rotation shaft, and the 2nd rotation shaft and the 1st arm, the 2nd arm, the lower paragraph, and the back paragraph soffit paragraph.
[0014] The many articulated robots concerning invention according to claim 3 The length of the angle and the back paragraph soffit paragraph over the back paragraph of the back paragraph soffit paragraph, and the mass of a weight The gravity which acts on the torque of the angular acceleration of the operating time of the 1st rotation shaft and the 2nd rotation shaft, the 1st rotation shaft, and the 2nd rotation shaft, the 1st rotation shaft, and the 2nd rotation shaft and the 1st arm, the 2nd arm, the lower paragraph, and the back paragraph soffit paragraph determines.
[0015] The many articulated robots concerning invention according to claim 4 limit the operating range to which a robot actually works, and determine the length of the angle and the back paragraph soffit paragraph over the back paragraph of the back paragraph soffit paragraph, and the mass of a weight.
[0016]
[Embodiments of the Invention] Hereafter, one form of implementation of this invention is explained.
It is the robot drum section by which 1 was prepared in a robot's pedestal and 2 was prepared on this pedestal 1, and a revolution drive is carried out [in / drawing / form 1. drawing 1 of operation is the block diagram showing the parallel link formula perpendicular many articulated robots by the form 1 of implementation of this invention, and] by the robot drum section driving source (not shown). The 1st rotation shaft with which 3 was pivoted in the robot drum section 2, and 4 are the 1st arm, it is fixed to the 1st rotation shaft 3, and the soffit of this 1st arm 4 rotates to the circumference of the 1st rotation shaft 3 by the 1st rotation shaft driving source (not shown). The 2nd rotation shaft with which 5 was pivoted by the 1st arm 4, and 6 are the 2nd arm, it is fixed to the 2nd rotation shaft 5, and this 2nd arm 6 is rotated centering on the 2nd rotation shaft 5 by the 2nd rotation shaft driving source (not shown). 7 is the 2nd arm back end paragraph, and is the portion which extended the 2nd arm 6 from the 2nd rotation shaft 5 to back (the side to which a robot works is made into the front). The lower paragraph with which 8 was connected free [the rotation to the circumference of the 1st rotation shaft 3] for an end, and the other end was connected with back Section 9 free [rotation], and 9 are the back paragraphs connected so that the edge of 2nd arm back end Section 7 and the edge of lower Section 8 might be connected and it might become parallel to the 1st arm 4 free [each edge and rotation]. The 1st arm 4, 2nd arm back end Section 7, lower Section 8, and back Section 9 have accomplished the parallel link of Section 4 here.
[0017] 11 is the deutomerite soffit paragraph which extended the deutomerite 9 to the 2nd arm 6 and the opposite side, and has extended only the predetermined angle phi and predetermined length r to the deutomerite 9. 10 is the weight prepared in the soffit of deutomerite soffit Section 11. 12 is the wrist shaft (grasping means) prepared in the front end (the side to which a robot works is made into the front) of the 2nd arm 6, and this wrist shaft 12 maintains a horizontal irrespective of the posture of the 1st arm 4 and the 2nd arm 6 by the parallel link (not shown) attached along with the 1st arm 4 and the 2nd arm 6 from the robot drum section 2. 13 is prepared in the bottom of the wrist shaft 12, it is the hand (grasping means) in which a rotation drive is carried out by the wrist shaft driving source (not shown), and this hand 13 grasps a work 14 according to the force of a hand driving source (not shown). In addition, the above-mentioned robot drum section driving source, the 1st rotation shaft driving source, the 2nd rotation shaft driving source, and a wrist shaft driving source consist of a motor, a reducer, or an air cylinder, and are controlled by the control unit (not shown) installed in a robot's exterior (or interior).
 [0018] Next, operation is explained. Drawing 2 is a schematic diagram for giving explanation of parallel link formula perpendicular many articulated robots of operation, and expresses the 1st arm 4, the 2nd arm 6, lower Section 8, the deutomerite 9, deutomerite soffit Section 11, etc. with the line. Since deutomerite soffit Section 11 tends to become a moment arm and it is going to raise the 1st arm 4 with the mass of a weight 10 about the 1st rotation shaft 3 when the 1st rotation shaft 3 rotates and the 1st arm 4 falls before, as shown in drawing 2 (a), the gravity load of the 1st arm 4 is mitigated. At this time, the predetermined angle phi and predetermined length r to the mass of a weight 10 and the deutomerite 9 of deutomerite soffit

Section 11 are adjusted so that a gravity load may be mitigated most. Moreover, since lower Section 8 tends to become a moment arm and it is going to raise the 2nd arm 6 with the mass of a weight 10 about the 2nd rotation shaft 5 when the 2nd rotation shaft 5 rotates and the 2nd arm 6 becomes level, as shown in drawing 2 (b), the gravity load of the 2nd arm 6 is mitigated. At this time, the predetermined angle phi and predetermined length r to the mass of a weight 10 and the deutomerite 9 of deutomerite soffit Section 11 are adjusted so that a gravity load may be mitigated most.
[0019] As mentioned above, according to the form 1 of this operation, in case the gravity load of the 1st arm 4 and the 2nd arm 6 is simultaneously mitigated using a weight 10, the optimal gravity unloading can be obtained by changing length r of an angle phi and back paragraph soffit Section 11 to back Section 9 of back paragraph soffit Section 11, and making the attaching position of a weight 10 the optimal. Moreover, since the predetermined angle [as opposed to back Section 9 of back paragraph soffit Section 11 for the attaching position of a weight 10] phi is given, even if it does not make mass of a weight 10 not much heavy, a gravity load is fully mitigable.
[0020] Although a gravity load is mitigated with the gestalt 1 of the gestalt 2. above-mentioned implementation of operation by attaching a weight 10 in the soffit of deutomerite soffit Section 11, and adjusting length r of an angle phi and deutomerite soffit Section 11 to the mass of a weight 10, and the deutomerite 9 of deutomerite soffit Section 11, the mass of the optimal weight 10 for gravity unloading, an angle phi, and length r are determined with the gestalt 2 of this operation. Drawing 3 is the schematic diagram showing the parallel link formula perpendicular many articulated robots by the gestalt 2 of implementation of this invention, and is set to drawing. theta 2 The angle of the 1st rotation shaft 3 (angle of the 1st arm 4 to a normal axis), theta 3 The angle (angle of the 2nd arm 6 to a horizontal axis) of the 2nd rotation shaft 5, and L1 The length of the 1st arm 4, and L2 The length of the 2nd arm 6, and LW They are the angle of deutomerite soffit Section [as opposed to / as opposed to / the length of deutomerite soffit Section 11 / in the length of lower Section 8, and r] the deutomerite 9 in phi / 11, and mc. It is the mass of a weight 10.
[0021] Next, mass mc of a weight 10 How to determine the angle phi of back paragraph soffit Section 11 and length r of back paragraph soffit Section 11 to back Section 9 is explained. First, the gravity unloading method about the 1st rotation shaft 3 is explained. Torque t2 which should be added to the reducer output shaft of the 1st rotation shaft 3 It becomes like an outline degree type. In addition, right-handed rotation is made positive about the right-hand side.
[0022]
t2 =-(Iw2+Ic2) *beta2+mw2*g*L1 *Sin(theta 2)-mc *g*r*Sin (theta2+phi) (1)
[0023] The value of each term is defined as follows here. t2 The torque and beta 2 which should be added to the reducer output shaft of the 1st rotation shaft 3 The equivalent mass (I think that this equivalent mass acts on an elbow) of an elbow (2nd rotation shaft 5) to the point and g of the angular acceleration of the reducer output shaft of the 1st rotation shaft 3 and mw2 are gravitational acceleration. Moreover, Iw2 is the moment of inertia of the circumference of the 1st rotation shaft 3 by the equivalent mass of an elbow to the point, and is set to Iw2=mw2*L1 *L1. Ic2 is the moment of inertia of the circumference of the 1st rotation shaft 3 by the weight 10, and serves as Ic2=mc *r*r.
[0024] Although the optimal attaching position and mass of a weight were determined from the formula of balance of static parallel link of Section 4 in the conventional example 3, the optimal attaching position and mass of a weight are determined from the formula of this working balance with the form 2 of this operation supposing the case where the robot is actually operating (work). Therefore, by the formula 1, torque and not only the gravity that acts on each paragraph but the force (angular-motion equation) of acting with angular acceleration is taken into consideration (the inside of a formula 1, and (Iw2+Ic2) *beta2).
[0025] Left part t2 of a formula 1 Suppose that the output tr2 of a reducer was applied. Here, tr2 is the permission maximum torque of the reducer of the 1st rotation shaft 3. t2 =tr2 -- setting -- this -- angular acceleration beta 2 of the 1st rotation shaft 3 ******** -- it is as follows if it solves
[0026]
beta2 =(tr2+mw2*g*L1 *Sin(theta 2)-mc *g *r*Sin (theta2+phi))/(mw2*L1 *L1+mc *r*r)
(2)
[0027] A known value is substituted for the above-mentioned formula 2. Known values are tr2 (the

maximum permissible torque of a reducer), L1 (the length of the 1st arm 4), and mw2 (equivalent mass of an elbow to the point) and g (gravitational acceleration). Here, tr2 makes right-handed rotation positive. The angle phi of back paragraph soffit Section [as opposed to the mass mc of a weight 10, length / of back paragraph soffit Section 11 / r, and back Section 9 for the substituted result] 11, and angle theta 2 of the 1st rotation shaft 3 It is referred to as function beta2pls.
[0028] Similarly, a known value is substituted for the above-mentioned formula 2. Although known values are tr2 (the maximum permissible torque of a reducer), L1 (the length of the 1st arm 4), and mw2 (equivalent mass of an elbow to the point) and g (gravitational acceleration) like the above-mentioned angular-acceleration beta2pls, tr2 is taken as negative as left-handed rotation. The angle phi of back paragraph soffit Section [as opposed to the mass mc of a weight 10, length / of back paragraph soffit Section 11 / r, and back Section 9 for the substituted result] 11, and angle theta 2 of the 1st rotation shaft 3 It is referred to as function beta2mns.
[0029] Angular-acceleration beta2pls and beta2mns It finds the integral over a robot's operating-range whole region. A robot's operating range is theta 2. It is until it results [from theta2l.] in theta2u. The soffit of a robot's operating range and theta2u of theta2l. are the upper limits of a robot's operating range. Thus, the called-for function is set to performance-index ea2pls which determines length r of back paragraph soffit Section 11, and an angle phi, and ea2mns. This performance-index ea2pls and ea2mns It is as follows.
[0030]
[Equation 1]

$$e_{a2pls} = \int_{\theta 2l}^{\theta 2u} \beta_{2pls} d\theta \quad \cdots (3)$$

$$e_{a2mns} = \int_{\theta 2l}^{\theta 2u} -\beta_{2mns} d\theta \quad \cdots (4)$$

[0031] In addition, counterclockwise angular-acceleration ea2mns Since it is related, it becomes negative and minus sign is attached, the one where right-handed rotation and left-handed rotation have a larger numeric value has large angular acceleration. Therefore, length r of back paragraph soffit Section 11 and an angle phi are determined so that this performance-index ea2pls and ea2mns may become large.
[0032] Drawing 4 (a) is performance-index ea2pls. It is an example which plotted length r of back paragraph soffit Section 11, and the angle phi as a variable. However, the constant of each part is defined as follows.
The maximum torque tr2 **3000Nm The length of the 1st arm L1 1.2m Equivalent function of an elbow to the point mw2 150kg Operating range of the 2nd shaft theta 2 Like -45deg - 90deg drawing 4 (a), length r of back paragraph soffit Section 11 becomes large, and an angle phi is [the smaller one / performance-index ea2pls] performance-index ea2pls. It receives and does not influence greatly.
[0033] Drawing 4 (b) is performance-index ea2mns. It is an example which plotted length r of back paragraph soffit Section 11, and the angle phi as a variable. In addition, the constant of each part is the same as that of the case of above-mentioned drawing 4 (a). Like drawing 4 (b), the maximal value exists to length r of back paragraph soffit Section 11, and the combination of an angle phi.
[0034] It is made for the angular acceleration of the performance index to become large about a performance index with smaller angular acceleration as an example which determines the optimal attaching position of a weight 10 here. That is, the portion to which angular acceleration becomes small is avoided. In this case, it is made for performance-index ea2mns (absolute value) to become large. Therefore, the maximum point of drawing 4 (b) serves as length r of back paragraph soffit Section 11, and an optimum value of an angle phi about the 1st rotation shaft 3, and serves as r=0.24mphi=60deg.
[0035] Next, the gravity unloading method about the 2nd rotation shaft 5 is explained. Torque t3 which should be added to the reducer output shaft of the 2nd rotation shaft 5 It becomes like an

outline degree type. In addition, right-handed rotation is made positive.
[0036]
t3 =(Iw3+Ic3) *beta3+mw3*g*L2 *Cos (theta 3)
- Mc *G*Lw *Cos (Theta 3) (5)
[0037] The value of each term is defined as follows here. t3 The torque and beta 3 which should be added to the reducer output shaft of the 2nd rotation shaft 5 The angular acceleration of the 2nd rotation shaft reducer output shaft and mw3 are the equivalent masses (I think that this equivalent mass starts a wrist shaft) of the wrist shaft 12.
Moreover, moment-of-inertia Iw3=mw3*L2 *L2Ic3 of the circumference of the 2nd rotation shaft 5 according [Iw3] to the equivalent mass of the wrist shaft 12 is moment-of-inertia Ic3=mc *Lw *Lw of the circumference of the 2nd rotation shaft 5 by the weight 10.
[0038] By the formula 5, the optimal attaching position and mass of a weight 10 are determined from the formula of this working balance like a formula 1 (formula about the 1st rotation shaft 3) supposing the case where the robot is actually operating (work). Therefore, by the formula 5, torque and not only the gravity that acts on each paragraph but the force (angular-motion equation) of acting with angular acceleration is taken into consideration (the inside of a formula 5, and (Iw3+Ic3) *beta3).
[0039] Left part t3 of a formula 5 Suppose that the output tr3 of a reducer was applied. Here, tr3 is the permission maximum torque of the reducer of the 2nd rotation shaft 5. t3 =tr3 -- setting -- this -- angular acceleration beta 3 of the 2nd rotation shaft 5 ******** -- it is as follows if it solves
[0040]
beta3 =(tr3+mw3*g*L2 *Cos(theta 3)-mc *g*Lw *Cos (theta 3))/(mw3*L2 *L2+mc *Lw *Lw) (6)
[0041] Angular acceleration beta 3 of the above-mentioned formula 6 A known value is substituted. Known values are tr3 (the maximum permissible torque of a reducer), L2 (the length of the 2nd arm 6), Lw (the length of lower Section 8), and mw3 (equivalent mass of the wrist shaft 12) and g (gravitational acceleration). Here, tr3 makes right-handed rotation positive. The substituted result is set to function beta3pls of the mass mc of a weight 10.
[0042] Similarly, a known value is substituted for the above-mentioned formula 6. Although known values are tr3 (the maximum permissible torque of a reducer), L2 (the length of the 2nd arm 6), Lw (the length of lower Section 8), and mw3 (equivalent mass of a wrist) and g (gravitational acceleration) like the above-mentioned angular-acceleration beta3pls, tr3 makes left-handed rotation positive. It is the mass mc of a weight 10 about the substituted result. Angle theta 3 of the 2nd rotation shaft 5 It is referred to as function beta3mns.
[0043] It integrates with angular-acceleration beta3pls and beta3mns over a robot's operating-range whole region. A robot's operating range is theta 3. It is until it results [from theta3l.] in theta3u. The soffit of a robot's operating range and theta3u of theta3l. are the upper limits of a robot's operating range. Thus, it is the mass mc of a weight 10 about the called-for function. Performance-index ea3pls to determine and ea3mns It carries out. This performance-index ea3pls and ea3mns It is as follows.
[0044]
[Equation 2]

$$e_{a3pls} = \int_{\theta 3l}^{\theta 3u} \beta_{3pls} d\theta \quad \cdots (7)$$

$$e_{a3mns} = \int_{\theta 3l}^{\theta 3u} -\beta_{3mns} d\theta \quad \cdots (8)$$

[0045] In addition, counterclockwise angular-acceleration ea3mns Since it is related, it becomes negative and minus sign is attached, the one where right-handed rotation and left-handed rotation have a larger numeric value has large angular acceleration. Therefore, this performance-index ea3pls and ea3mns It is the mass mc of a weight 10 so that it may become large. It determines.
[0046] Drawing 5 is performance-index ea2pls and ea3mns. Mass mc of a weight 10 It is an example

plotted as a variable. However, the constant of each part is defined as follows.
Maximum torque tr3 **3000Nm The length of the 2nd arm L2 1.2m Equivalent function of an elbow to the point mw3 100kg Operating range of the 2nd shaft theta 3 -15deg-90deg performance-index ea2pls As the solid line of drawing 5 shows, it is the mass mc of a weight 10. The larger one is performance-index ea2pls. It becomes small. On the other hand, it is performance-index ea3mns. As the dashed line of drawing 5 shows, it is the mass mc of a weight 10. The larger one is performance-index ea3mns. It becomes large.
[0047] Here, it is the mass mc of a weight 10. It is made for a portion with small angular acceleration (absolute value) to decrease as an example to determine. Therefore, performance-index ea3mns of clockwise performance-index ea2pls and clockwise left-handed rotation is piled up, and these intersections serve as the optimal mass. Mass mc of the weight 10 at this time It is set to 400kg.
[0048] In addition, mass mc of the weight 10 for which it asked as mentioned above When a size is too large in respect of for example, an installation size etc., since it is better as it is large, it should just make it heavy as much as possible in the realistic range.
[0049] As mentioned above, the optimal attaching positions r and phi and mass mc of a formula to the weight 10 of the working balance which took angular acceleration into consideration supposing the case where the robot is actually operating (work) according to the form 2 of this operation Since it determines In order to mitigate a gravity load, even if it attaches a weight 10, the effect that the fall of the angular acceleration of the 1st rotation shaft 3 (or the 1st arm 4) and the 2nd rotation shaft 5 (or the 2nd arm 6) can be prevented is acquired.
[0050] Although the angular acceleration of the 1st rotation shaft 3 and the 2nd rotation shaft 5 fell and had determined the performance index from a viewpoint [that there needs to be nothing] with the form 2 of the form 3. above-mentioned implementation of operation, a performance index is decided from a viewpoint of making it a robot's operating time become shorter, with the form 3 of this operation. It is drawing showing the relation between the angular velocity of the 1st rotation shaft 3 of the perpendicular many articulated robots by the form 3 of implementation of this invention, and the 2nd rotation shaft 5, time, and the degree of operating angle, it sets to drawing, and drawing 6 is ta. The acceleration time and td The deceleration time and betaa Angular acceleration (acceleration) and betad Angular acceleration (slowdown) and theta are the degrees of operating angle. A robot's 1st rotation shaft 3 and the 2nd rotation shaft 5 accelerate and slow down to the circumference of a certain angle in operating range, and show the small case where angle operation is being carried out. Let the value which integrated with the sum of the operating time at this time, i.e., the acceleration time, and the deceleration time over a robot's operating-range whole region be a performance index.
[0051] Since maximum velocity (M shows among drawing) is equal so that clearly from drawing 6 , the following formula is realized.
[0052]
betaa *ta =betad *td (9)
[0053] Moreover, the following formula is realized using the degree theta of operating angle (area surrounded with the triangle in drawing).
[0054]
betaa *ta2/2+betad *td2/2=theta (10)
[0055] The above-mentioned formula 9 and a formula 10 to the operating time t is [0056].
[Equation 3]

$$t=t_a+t_d=\frac{\sqrt{2(\beta_a+\beta_d)\theta}}{\sqrt{\beta_a}\sqrt{\beta_d}} \quad \cdots (11)$$

[0057] It becomes. Here, a performance index to which the operating time becomes short is searched for about the 1st rotation shaft 3. Performance-index ea2pls of the angular acceleration of the 1st rotation shaft 3 searched for with the form 2 of the above-mentioned implementation and ea2mns (a formula 3, formula 4) are substituted for the above-mentioned formula 11, and a performance index

eb2 is defined like the following formula.
[0058]
[Equation 4]

$$e_{b2}=\int_{\theta_{2l}}^{\theta_{2u}}\frac{\sqrt{\beta_{2pls}-\beta_{2mns}}}{\sqrt{\beta_{2pls}}\sqrt{-\beta_{2mns}}}d\theta \quad \cdots (12)$$

[0059] In addition, the term of coefficient root (2) and theta is removed by this formula 12. Moreover, since beta2mns is negative, minus sign is attached in order to just carry out. In order for the operating time to become short, length r of back paragraph soffit Section 11 and an angle phi are determined such that this performance index eb2 should just become small.
[0060] Drawing 7 (a) is drawing showing an example which plotted length r of back paragraph soffit Section 11, and the angle phi for the performance index eb2 as a variable. Here, the constant of each part is the same as the case of the form 2 of the above-mentioned implementation. As shown in drawing 7 (a), the minimal value exists to combination with length r of back paragraph soffit Section 11, and an angle phi. Therefore, length r of back paragraph soffit Section 11 and the value of an angle phi in the minimal value turn into an optimum value. An optimum value serves as r=0.2mphi=8deg.
[0061] Next, a performance index to which the operating time becomes short is searched for about the 2nd rotation shaft 5. It is given by the formula 11 and the operating time t as well as the performance index eb2 about the 1st rotation shaft 3 is [0062].
[Equation 5]

$$t=\frac{\sqrt{2\ (\beta_a+\beta_d)\ \theta}}{\sqrt{\beta_a}\ \sqrt{\beta_d}} \quad \cdots (13)$$

[0063] It comes out. angular-acceleration beta3pls of the 2nd rotation shaft 5 for which this formula 13 (a formula 11 -- the same) was asked with the form 2 of the above-mentioned implementation, and beta3mns (a formula 7, formula 8) are substituted, and a performance index eb3 is defined as follows
[0064]
[Equation 6]

$$e_{b3}=\int_{\theta_{3l}}^{\theta_{3u}}\frac{\sqrt{\beta_{3pls}-\beta_{3mns}}}{\sqrt{\beta_{3pls}}\sqrt{-\beta_{3mns}}}d\theta \quad \cdots (14)$$

[0065] In addition, the term of coefficient root (2) and theta is removed by this formula 14. Moreover, since beta3mns is negative, minus sign is attached in order to just carry out. In order for the operating time to become short, the mass mc of a weight 10 is determined such that this performance index eb3 should just become small.
[0066] Drawing 7 (b) is the mass mc of a weight 10 about a performance index eb3. It is drawing showing an example plotted as a variable. Here, the constant of each part is the same as the case of the form 2 of the above-mentioned implementation. As shown in drawing 7 (b), it is the mass mc of a weight 10. It receives and the minimal value exists. Therefore, mass mc of the weight 10 in the minimal value A value turns into an optimum value. An optimum value is set to mc =240kg.
[0067] as mentioned above -- according to the form 3 of this operation -- the operating time of the 1st rotation shaft 3 and the 2nd rotation shaft 5 -- using -- a performance index -- asking -- thereby -- length [of back paragraph soffit Section 11] r, an angle phi, and mass mc of a weight 10 Since it

determines In order to mitigate a gravity load, even if it attaches a weight 10, the effect that the operating time of the 1st rotation shaft 3 (or the 1st arm 4) and the 2nd rotation shaft 5 (or the 2nd arm 6) can be shortened is acquired. Moreover, when a robot's 1st rotation shaft 3 and the 2nd rotation shaft 5 reach the upper limit of angular velocity immediately, a gravity load can be mitigated more efficiently than the method using the angular acceleration shown with the form 2 of the above-mentioned implementation (when reaching the upper limit of angular velocity in small angle operation).

[0068] With the forms 2 and 3 of the form 4. above-mentioned implementation of operation, the value which integrated with angular acceleration or the operating time within the limits of this was used as a performance index supposing the case where a robot operates throughout the operating range of the 1st rotation shaft 3 and the 2nd rotation shaft 5 (theta2 l<=theta<=theta 2u, theta3l<=theta<=theta3u). However, this performance index is included in the range of integration to a range which the wrist shaft 12 does not reach, when actually working. Then, with the form 4 of this operation, it limits to the operating range to which a robot actually works, and a performance index is searched for. Drawing 8 is drawing showing an actual operating range of the perpendicular many articulated robots by the form 4 of implementation of this invention. Each point in drawing plots wrist shaft 12 position when being in the operating range of each shaft and moving a robot's 1st rotation shaft 3 and the 2nd rotation shaft 5 by a unit of 5 times. Moreover, the portion surrounded in the rectangle shows the operating range to which a robot actually works.

[0069] Although the range in which the wrist shaft 12 can operate is a falcation range which the point in drawing draws when a robot operates throughout the operating range of the 1st rotation shaft 3 and the 2nd rotation shaft 5, the operating range to which a robot actually works is the portion surrounded in the rectangle in drawing in many cases. Therefore, it integrates with angular acceleration or the operating time about the portion surrounded in the rectangle in drawing, and this value is used as a performance index.

[0070] the coordinate of the point within the limits surrounded in the rectangle of drawing 8 is set to (X, Z), and the angle of the 1st rotation shaft 3 when the wrist shaft 12 has reached this point (X, Z), and the 2nd rotation shaft 5 is shown in drawing 9 -- as (theta 2 and theta 3) -- **, if it carries out The coordinate (x z) of the wrist shaft 12 is the length L1 of the 1st arm 4, and the length L2 of the 2nd arm 6. It can use and can express as follows.

[0071]

X=SX+L1 Sin(theta 2)+L2 Cos(theta 3)+WX (15)

Z=SZ+L1 Cos(theta 2)-L2 Sin(theta 3)-WZ (16)

[0072] However, the coordinate of a robot's shoulder (1st rotation shaft 3), and (Wx and Wz) of (Sx and Sz) are the offset coordinates of a robot's wrist shaft 12. the angle theta 2 of the 1st [to the coordinate within the limits surrounded in the rectangle in drawing using the above-mentioned relational expression (a formula 15, formula 16)] rotation shaft 3, and the 2nd rotation shaft 5, and theta 3 asking -- the forms 2 and 3 of the above-mentioned implementation -- the same -- carrying out -- a performance index -- asking -- length r of back paragraph soffit Section 11, and an angle phi and the mass mc of a weight 10 What is necessary is just to optimize. In addition, when the coordinate of the lattice point of a fixed interval may be given within the limits of this, and work is concretely decided, when giving the coordinate within the limits surrounded in the rectangle in drawing, and a robot's orbit is decided, the orbit may be given, and you may give by random numbers using a Monte Carlo method further.

[0073] as mentioned above, the operating range to which a robot actually works according to the gestalt 4 of this operation -- restricting -- a performance index -- asking -- thereby -- length [of deutomerite soffit Section 11] r, an angle phi, and mass mc of a weight 10 Since it determines, a gravity load can be mitigated still more efficiently.

[0074] In addition, in the gestalten 2, 3, and 4 of the above-mentioned implementation, although mw2 was made into the equivalent mass of an elbow to the point and mw3 was only made into the equivalent mass of the wrist shaft 12 A robot's uses are a welding robot, a painting robot, etc., and it is decided, respectively that it will be a welding gun, the paint spray which it has in a hand. when a hand's mass is fixed A previous equivalent mass and mw3 become the equivalent mass of the wrist shaft 12 containing a hand's mass from the elbow in which mw2 contains a hand's mass. Moreover,

when there are a time of a robot assembling, being a robot, a palletizing robot, etc. and having a work in a hand's robot hand and a time of not having a work, the equivalent mass of the elbow in which mw2 contains one half of the mass of a work to the point, and mw3 become the equivalent mass of the wrist shaft 12 containing one half of the mass of a work so that a gravity compensation suitable in both cases may work.
[0075] In addition, in the gestalten 2 and 3 of the above-mentioned implementation, although the integration value of the angular acceleration or the operating time covering a robot's operating range was used as a performance index, you may use total (sigma) of the angular acceleration or the operating time over the angle given at intervals of [suitable] the integration value.
[0076] In addition, in the gestalten 2, 3, and 4 of the above-mentioned implementation, as threshold value (maximum) of torque, although the permission maximum torque of a reducer was used, depending on the case, you may use the maximum torque of a motor.
[0077]
[Effect of the Invention] As mentioned above, since according to invention according to claim 1 it constituted so that an end might hold the deutomerite and a predetermined angle, and it might have the deutomerite soffit paragraph attached in the other end of the deutomerite, and the weight attached in the other end of this deutomerite soffit paragraph In case the gravity load of the 1st arm and the 2nd arm is simultaneously mitigated using a weight, it is effective in the ability to obtain the optimal gravity unloading by changing the length of the angle and deutomerite soffit paragraph over the deutomerite of a deutomerite soffit paragraph, and making the attaching position of a weight the optimal. Moreover, since the predetermined angle [as opposed to the deutomerite of a deutomerite soffit paragraph for the attaching position of a weight] is given, even if it does not make mass of a weight not much heavy, there is an effect which can fully mitigate a gravity load.
[0078] According to invention according to claim 2, the length of the angle and deutomerite soffit paragraph over the deutomerite of a deutomerite soffit paragraph, and the mass of a weight Since it constituted so that the gravity which acts on the torque and the 1st arm, the 2nd arm, the lower paragraph, and deutomerite soffit paragraph of the angular acceleration of the 1st rotation shaft and the 2nd rotation shaft, the 1st rotation shaft, and the 2nd rotation shaft might determine In order to be able to determine the optimal attaching position and mass of a weight from the formula of the working balance in consideration of angular acceleration supposing the case where the robot is actually operating (work) and to mitigate a gravity load, even if it attaches a weight It is effective in the ability to prevent the fall of the angular acceleration of the 1st rotation shaft (or the 1st arm) and the 2nd rotation shaft (or the 2nd arm).
[0079] According to invention according to claim 3, the length of the angle and deutomerite soffit paragraph over the deutomerite of a deutomerite soffit paragraph, and the mass of a weight The angular acceleration of the operating time of the 1st rotation shaft and the 2nd rotation shaft, the 1st rotation shaft, and the 2nd rotation shaft, Since it constituted so that the gravity which acts on the torque and the 1st arm, the 2nd arm, the lower paragraph, and deutomerite soffit paragraph of the 1st rotation shaft and the 2nd rotation shaft might determine In order to search for a performance index using the operating time of each rotation shaft, to be able to determine the length of a deutomerite soffit paragraph, an angle, and the mass of a weight by that cause and to mitigate a gravity load, even if it attaches a weight It is effective in the ability to shorten the operating time of the 1st rotation shaft (or the 1st arm) and the 2nd rotation shaft (or the 2nd arm). Moreover, when a robot's rotation shaft reaches the upper limit of angular velocity immediately, there is an effect which can mitigate a gravity load more efficiently than the method using angular acceleration (when reaching the upper limit of angular velocity in small angle operation).
[0080] Since according to invention according to claim 4 it constituted so that the operating range to which a robot actually works might be limited and the length of the angle and the above-mentioned deutomerite soffit paragraph over the deutomerite of a deutomerite soffit paragraph and the mass of a weight might be determined Since a robot searches for a performance index only within the operating range which actually works and determines the length of a deutomerite soffit paragraph, an angle, and the mass of a weight by that cause, there is an effect which can mitigate a gravity load still more efficiently.

[Translation done.]

DESCRIPTION OF DRAWINGS

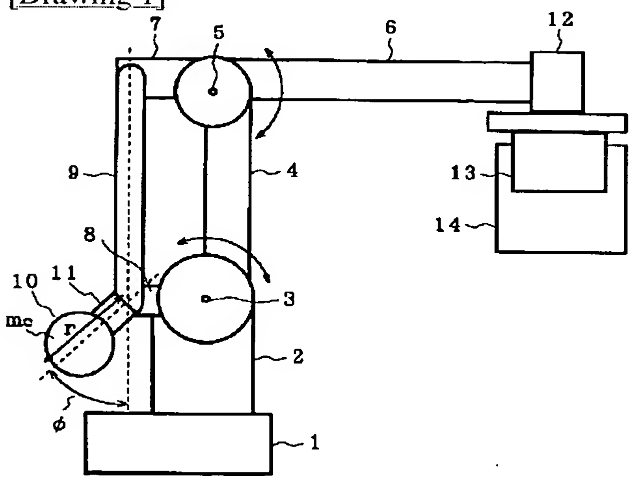
[Brief Description of the Drawings]
[Drawing 1] It is the block diagram showing the parallel link formula perpendicular many articulated robots by the gestalt 1 of implementation of this invention.
[Drawing 2] It is a schematic diagram for giving explanation of the parallel link formula perpendicular many articulated robots by the gestalt 1 of implementation of this invention of operation.
[Drawing 3] It is the schematic diagram showing the parallel link formula perpendicular many articulated robots by the gestalt 2 of implementation of this invention.
[Drawing 4] It is drawing showing an example which plotted length r of a deutomerite soffit paragraph, and the angle phi for performance-index e2pls and e2mns as a variable.
[Drawing 5] It is the mass mc of a weight about performance-index ea2pls and ea3mns. It is drawing showing an example plotted as a variable.
[Drawing 6] It is drawing showing the relation between the angular velocity of the 1st rotation shaft of the perpendicular many articulated robots by the gestalt 3 of implementation of this invention, and the 2nd rotation shaft, time, and the degree of operating angle.
[Drawing 7] It is the mass mc of a weight about drawing and the performance index eb3 which show an example which plotted length r of a deutomerite soffit paragraph, and the angle phi for the performance index eb2 as a variable. It is drawing showing an example plotted as a variable.
[Drawing 8] It is drawing showing an actual operating range of the perpendicular many articulated robots by the gestalt 4 of implementation of this invention.
[Drawing 9] It is the block diagram showing the perpendicular many articulated robots by the gestalt 4 of implementation of this invention.
[Drawing 10] It is the block diagram showing the conventional many articulated robots.
[Drawing 11] It is the block diagram showing the parallel link formula perpendicular many articulated robots shown in the real extraction-of-the-square-root No. 121682 [one to] official report.
[Drawing 12] It is drawing showing the gravity balancer of the many articulated robots shown in JP,7-16903,B.
[Drawing 13] It is the block diagram showing the perpendicular many articulated robots using the conventional spring.
[Description of Notations]
2 A robot drum section, 3 The 1st rotation shaft, 4 The 1st arm, 5 The 2nd rotation shaft, 6 The 2nd arm, 8 A bottom paragraph, 9 The deutomerite, 10 A weight, 11 A deutomerite soffit paragraph, 12 wrist shafts (grasping means), 13 A hand (grasping means), 14 Work.

[Translation done.]

* NOTICES *

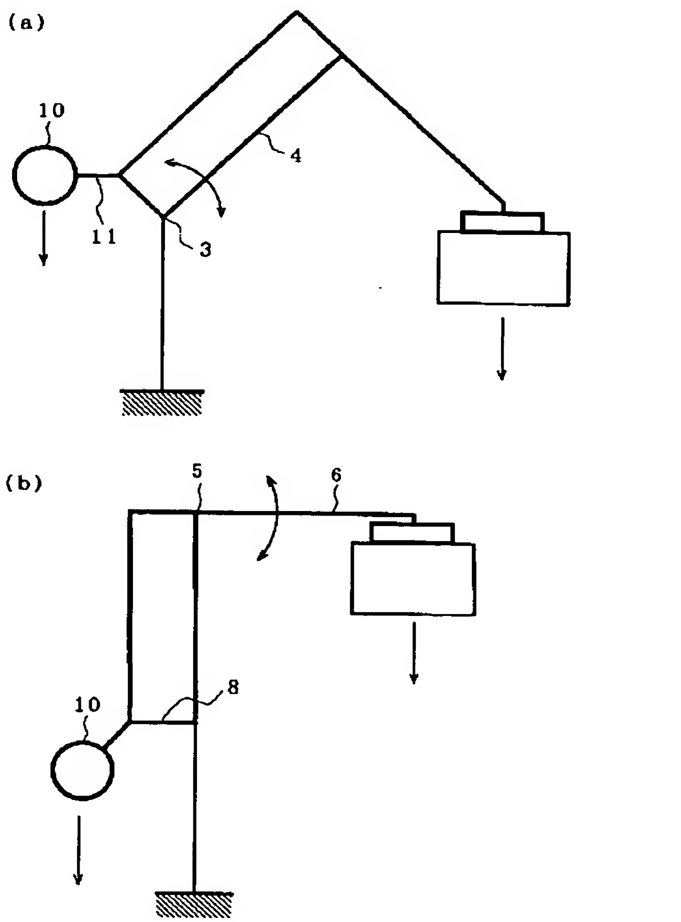
DRAWINGS

[Drawing 1]

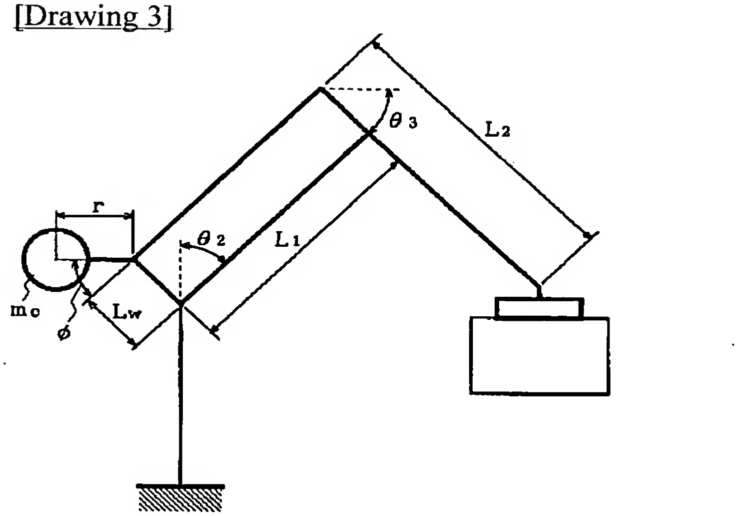


２：ロボット胴部
３：第１の回動軸
４：第１アーム
５：第２の回動軸
６：第２アーム
８：下節
９：後節
１０：重錘
１１：後節下端節
１２：手首軸（把持手段）
１３：ハンド（把持手段）
１４：ワーク

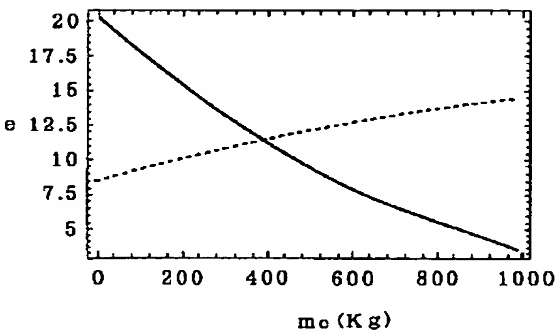
[Drawing 2]



[Drawing 3]

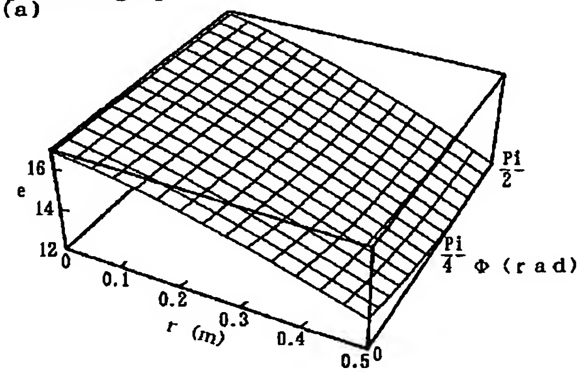


[Drawing 5]

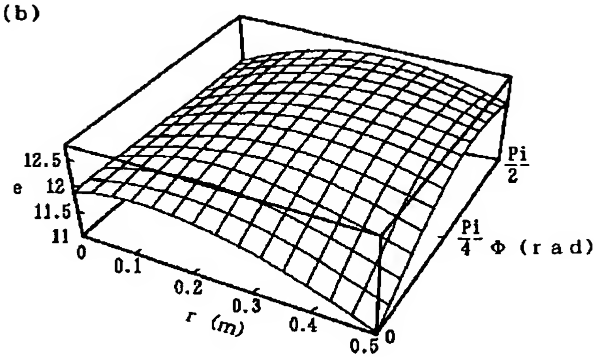


[Drawing 4]

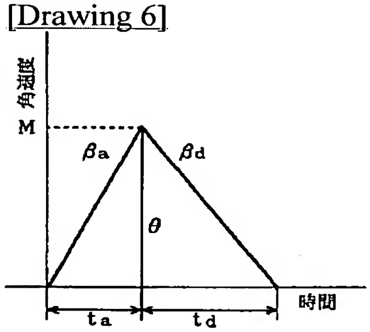
(a)



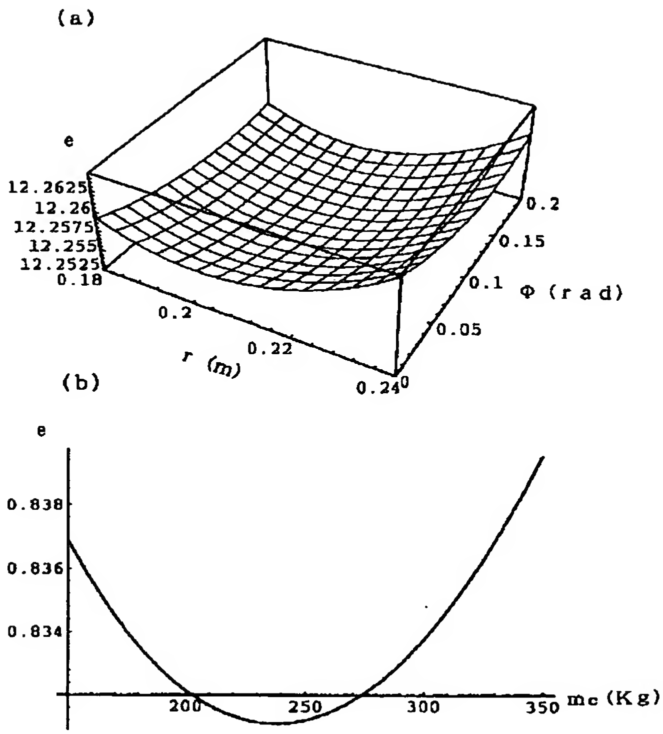
(b)



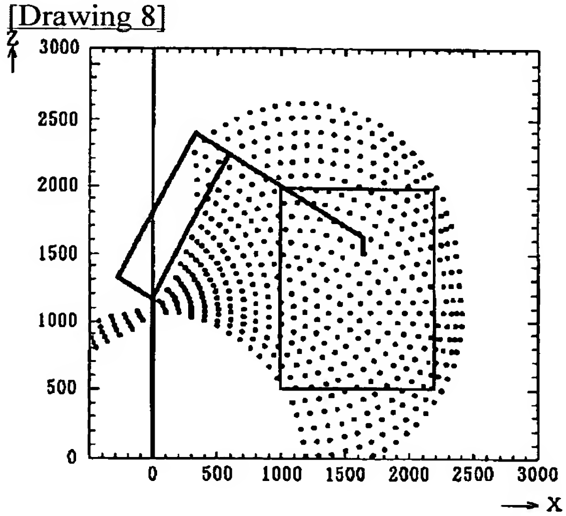
[Drawing 6]



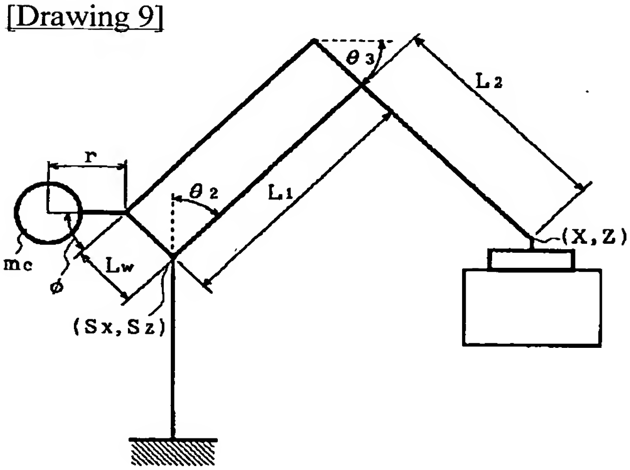
[Drawing 7]



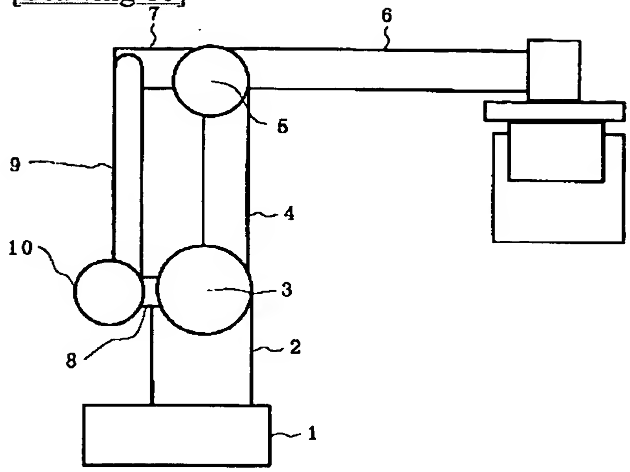
[Drawing 8]



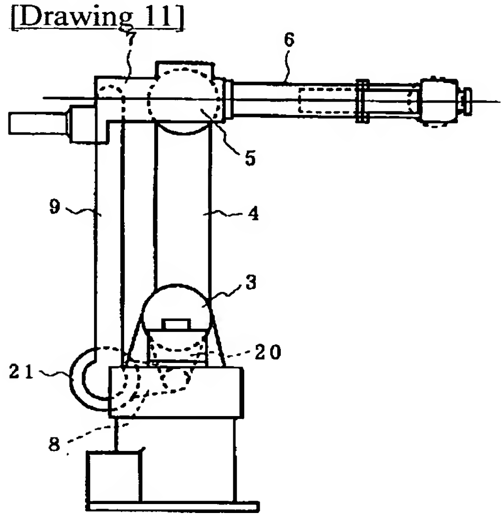
[Drawing 9]



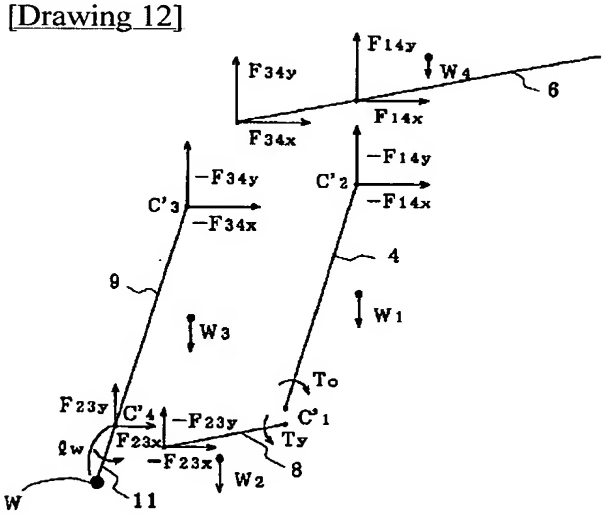
[Drawing 10]



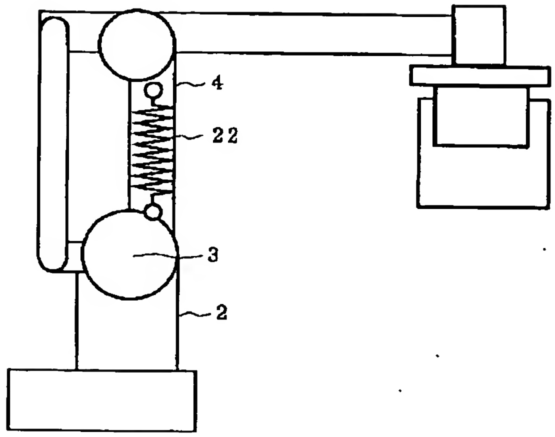
[Drawing 11]



[Drawing 12]



[Drawing 13]



[Translation done.]